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Carbon Black Increases Snowmelt and Forage Availability on Deer Winter Range in Colorado

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The use of carbon black offers a potential method of increasing the availability of deer forage on winter ranges in Colorado. On slopes with a southern exposure, over 40 cm of snow was melted to bare ground in February when air temperature averaged -8.8°C during daylight hours. Addition of the carbon black did not alter snow density.

Keywords: Forage availability, deer winter range, snowmelt, *Odocoileus hemionus.*

Availability of winter forage is an important factor limiting deer populations in much of North America. On many winter ranges, snow, more than any other factor, determines the availability of forage for deer (Gilbert and others 1970). The USDA Forest Service is therefore evaluating methods of manipulating snow cover to benefit deer.

Snowfences have effectively increased the availability of browse stands (Regelin 1974) by relocating snowdrifts, but often the snow falling directly upon the shrubs accumulates to depths that prohibit deer use. The possibility of reducing the depth of snow in such protected shrub stands by accelerating the snowmelt rate was examined in this study. Artificial darkening of the snow surface increases absorption of short-wave radiation, which increases the rate of snowmelt. Procedures based on this principle have been used for many years in Russia and Japan to accelerate spring snowmelt on airport landing strips and to increase summer runoff from glaciers. Slaughter (1966) cites numerous examples of such practices.

To date, most snowmelt experiments have been done in spring and early summer when temperatures are normally above freezing. Several papers report the influence of air temperature and new snowfall upon the melt rate of snow with an artificially darkened surface (Arnold 1960, Azuma 1956, Megahan 1968, Taketa and Murakami 1956). Many substances, including soil, coal dust, cinders, and carbon black, have been used. Megahan (1968) found carbon black much more effective in accelerating spring melt rate than other black materials. The purpose of this study was to determine the effectiveness of carbon black in causing midwinter snowmelt on deer winter ranges, and to determine whether such treatment changes snow density. The study was conducted under contract with the Colorado Division of Wildlife through Federal Aid in Wildlife Restoration Project W-38-R.

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Study Area and Methods

Seven sites were selected on Junction Butte, Grand County, Colorado, latitude 40° N., longitude 106° W. at 2,310 to 2,350 m elevation. Effects of windblown snow were minimized on all sites by natural windbreaks provided by dense stands of serviceberry (*Amelanchier alnifolia*) and other shrubs. Each site consisted of a treatment plot, 10 m², and an adjacent control plot of equal size. Plots were paired on the basis of similar aspect, slope, and vegetative cover. Four sites were located on a generally northerly aspect and three on a southerly aspect:

Site	Aspect (*degrees*)	Slope (*percent*)
1	180	20
2	170	18
3	200	17
4	140	3
5	55	6
6	105	9
7	95	9

Carbon black (Philblack N 550)[2] was applied to each treatment plot with a "whirlybird" backpack fertilizer spreader at the rate of 336 kg/ha (34.4 g/m²). The first application was made on January 30, 1974; two subsequent applications at the same rate were made on February 4 and 9, 1974. All applications were made during early morning hours with calm wind conditions, and resultant coverage was good. Treatments appeared as dark gray patches on the snow surface.

Snow depth in each treatment and control plot was measured daily at approximately 3:00 p.m. for 12 consecutive days after the first application of carbon black and on February 16, 16 days after the first application. Within each plot, 13 stakes marked in 10 cm increments were systematically located to facilitate snow-depth measurements. Snow density was measured at five locations within each plot using a Mount Rose snow sampler. Snow density was determined four times: before initial application of carbon black, before the two subsequent applications, and at the termination of the experiment. Hardness of the snow crust was recorded continuously near the plots.

Differences in snowmelt rate between treatment and control plots were so pronounced that statistical analysis was not considered necessary. Analysis of covariance was used to determine if snow density changed significantly.

Results and Discussion

Melting of snow was accelerated on all treated plots. The effect of the carbon black was more pronounced on the three sites with southerly aspect. Average snow depth was reduced by 91.8 percent, from 42.9 cm to 3.6 cm, compared to control plots where snow depth decreased naturally from 40.6 to 37.6 cm or 7.4 percent:

Date	Percent decrease in snow depth on: Southerly aspects	Easterly aspects[3]
January		
31	17.7	5.3
February		
1	30.8	6.6
2	31.9	[3]2.8
3	32.4	[3]2.8
4	36.1	5.3
5	37.3	[3]0
6	38.9	[3]0.4
7	38.9	[3]0
8	38.9	[3]0
9	49.3	4.7
10	59.2	8.4
11	67.4	18.1
12	79.2	23.8
16	91.8	50.5

Average snow depth on the plots with an easterly aspect was reduced by 50.5 percent, from 53.3 to 27.4 cm, while depth did not decrease on the control plots.

A light snowfall, 2 days after the first application, covered the carbon black with 2 to 3 cm of snow. No melt occurred on the plots with an easterly aspect for the next 2 days. Carbon black was applied again on February 4, but 7 to 8 cm of snow fell that evening. The carbon black was not visible through this layer of new snow and no melt occurred for the next 4 days. Clear, cold weather prevailed for several days after the third application of carbon black, on February 9, and snow melted rapidly on all sites. The quantity of carbon black on the snow surface was increased threefold after approximately 10 cm of snow melted because the two prior applications of carbon black were again on the snow surface.

[2]*Trade and company names are used for the benefit of the reader; such use does not constitute an official endorsement or approval of any service or product by the U.S. Department of Agriculture to the exclusion of others that may be suitable.*

[3]*Decreasing percentages indicate increases in snow depth due to new snowfall.*

At the termination of the study, 16 days after the first application and 7 days after the final application, all snow on the three treatment plots with southerly aspects had melted to bare ground except in small patches shaded by tall shrubs. The four treated plots with easterly aspects retained some snow, but small areas had melted to bare ground.

Maximum daily air temperature exceeded 0°C only twice during the study:

Date	Mean	High	Low
		- - (°C) - -	
January			
31	- 5.5	-0.6	-12.2
February			
1	- 5.2	-3.9	- 8.3
2	- 9.5	-5.6	-13.3
3	- 8.6	-1.7	-16.1
4	- 7.0	-1.1	-15.0
5	-10.6	-6.1	-12.2
6	- 9.9	-3.3	-17.8
7	-14.1	-8.9	-20.6
8	-15.2	-8.3	-25.0
9	-10.9	-3.3	-22.2
10	-10.4	-1.7	-19.4
11	- 8.6	-2.2	-19.4
12	- 4.6	-0.6	-11.6
13	- 5.4	+5.4	-15.6
14	- 7.1	+3.6	-19.4
15	- 8.1	0	-16.7

The average air temperature during daylight hours was -8.8° C. Water was observed near edges of the treatment plots when air temperature was -16° C. Temperature was not measured at the snow-atmosphere interface.

Analysis of covariance was used to test differences in snow density. Treated snow was slightly denser than on the control plots prior to both the second and third applications of carbon black, but the differences were not statistically significant ($P<0.20$). Snow-crust hardness values were too variable within both treatment and control plots to justify statistical analysis. General observations indicated that treatment with carbon black did not greatly alter the hardness of snow crust until snow depth was shallow, 4-8 cm. At this time, the rapidly melting snow was wet and slushy, and would form an ice crust at night.

Management Implications

After the treated plots had melted to bare ground, the control plots remained snow covered for 4 weeks (to about March 15). Green vegetation was apparent early on the melted plots. Since deer are reaching their poorest physical condition in this period, the implications to management are obvious. Although new snowfall may negate or delay the melting effect, solar radiation is intensifying rapidly by late February, when forage needs are most critical, and the incidence of heavy snowstorms is decreasing on low-elevation winter ranges. Thus the probability of successful treatment is good.

Effects of the carbon black on vegetation were not investigated. While no influences were apparent from subjective examination the following summer, the long-term effects of residual carbon black on soil structure, soil moisture, plant phenology, growth rates, palatability, and so forth, should be studied.

Only in Finland (Rakkolainen 1971) has a blackening agent been applied extensively as a wildlife management tool. There, treatment of 180 ha with soot and "forest fertilizer" reportedly improved nesting conditions for black grouse (*Lyrurus tetrix*).

Currently, carbon black could be applied aerially at approximately $12 per ha. In the area where the present study was done (Middle Park, Colorado), approximately 10,000 mule deer (*Odocoileus hemionus*) spend the late winter on less than 2,600 ha of range. In some years thousands of deer die of starvation in February and March in this area (Wallmo and Gill 1971). Application of carbon black to selected, highly productive, snow-covered sites totaling no more than 100 ha could increase the availability of forage appreciably. If this practice were to prevent the death of several hundred deer and improve the condition of surviving does in late pregnancy, its effect on the population might be considerable.

Carpenter (1972) reported that nitrogen fertilizer increased herbage yields up to 87 percent and stimulated forage to initiate growth several weeks earlier on selected areas within this same winter range. Williams (1972) found that protein content of the net growth was appreciably increased. It is conceivable that a combination of carbon black and nitrogen fertilizer could compound these benefits at an application cost only slightly higher than for either applied separately.

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